Science around the planet uses images of Earth from the space station

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An image of the city of Chicago at night taken by crew aboard the International Space Station. Scientists have used images such as this one in studies demonstrating the effects of artificial light on urban wildlife and research on the proximity of urban greenspaces to residential areas. Credit: Earth Science and Remote Sensing Unit, NASA Johnson Space Center

Artificial lighting at night affects the behavior of urban wildlife, according to a recent study published in *Nature Scientific Reports*, which examined animals in the laboratory and the field. The researchers mapped light levels in the city of Chicago using publicly available images of Earth taken by astronauts from the International Space Station.

The study is only one example of the wide variety of scientific research based on images taken by crew members from space using the Crew Earth Observations (CEO) facility. Other recent research used these images to show that urban green areas, which contribute to human well-being, are rarely in close proximity to where people live. Another study relied on CEO images to create population maps, an important tool for urban planning, resource allocation and disaster prevention and response.

"Astronaut photography from the space station provides regional and global perspectives of land surfaces and what is changing on those land surfaces," said William Stefanov, manager of NASA's Exploration Science Office at Johnson Space Center and principal investigator for CEO. "The images allow a look at a much broader area, and those regional processes and relationships often become much more obvious when seen from that perspective. It allows you to see the whole picture beyond the fine view you have on the ground."

Most orbiting satellites collect data at the same place and about the same time of day for set intervals of time. The space station's inclined equatorial orbit takes its cameras over different parts of the planet at different times, and the station revisits sites at variable intervals, making it possible to collect images from many areas at varying times of day and night.

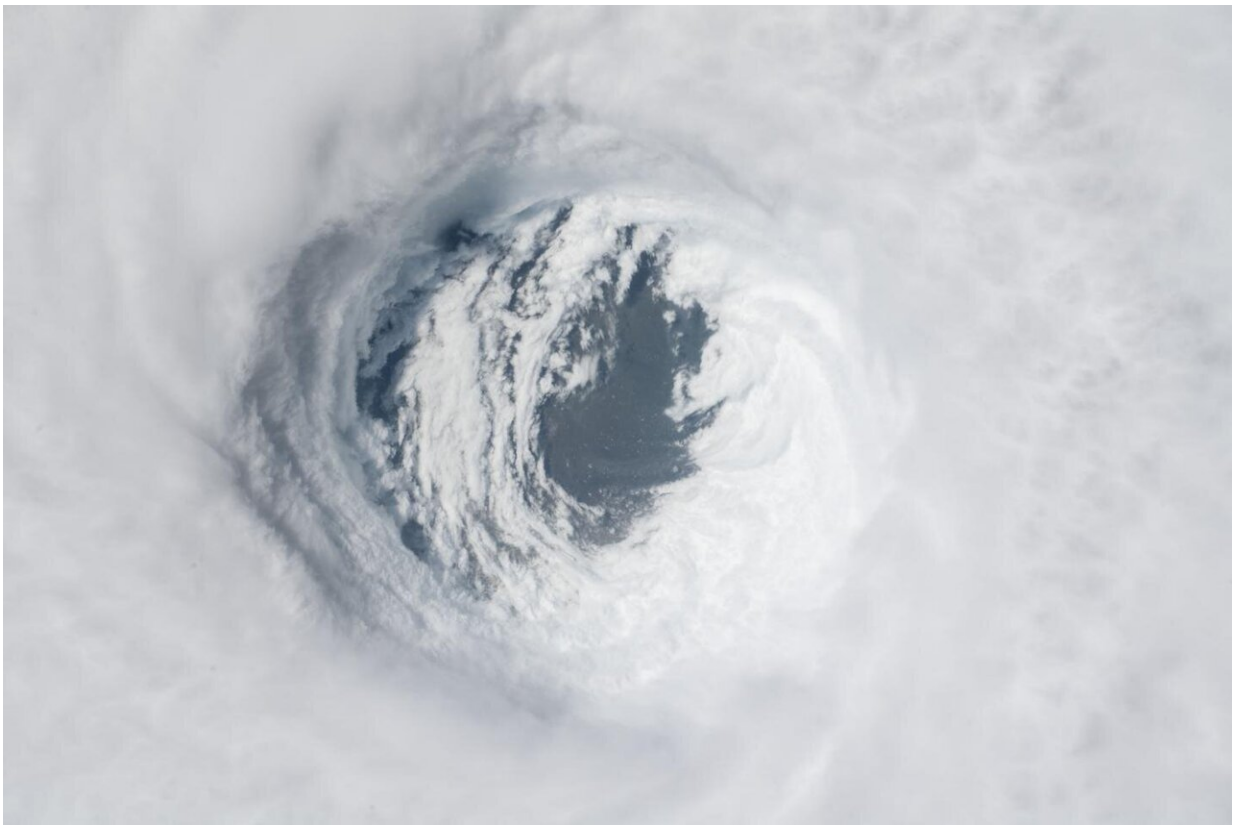

Image from the Gateway to Astronaut Photography of Earth collection shows the eye of 2018's Hurricane Michael. Such images contribute to preparation and planning for disaster response efforts. Credit: Earth Science and Remote Sensing Unit, NASA Johnson Space Center

"That opens up possibilities to investigate a lot of processes," said Stefanov. "Researchers can compare areas to each other and see changes on a broader scale that you might not notice on a smaller spatial scale and fixed time interval. Things such as how urban lighting patterns change over time, or tracking the recovery of power following a major storm, as represented by lighting."

CEO images currently support a number of urban night lighting studies, glacier and volcano monitoring, and studies of atmospheric processes

such as the frequency of lightning flashes. The images also are used in ecological studies, including a collaborative project called Aviation Migration Aerial Surface Space (AMASS), which tracks bird migration routes and the effects of changes occurring along those routes.

Astronaut photography also supports NASA Disaster Response, a program that works with a number of NASA centers to collect data before, during and following a disaster. "The CEO facility is still the workhorse for data collection on the space station for responding to disasters," Stefanov said. "Images can show the structure of hurricanes and tropical storms before landfall, and post-storm images of affected areas reveal the extent of flooding and damage." For wildfires, the images can identify smoke plume location and extent.

In addition, NASA delivers imagery to the US Geological Survey's Hazards Data Distribution System, which provides access to remotely sensed imagery and other data as they become available during a disaster response. Internally, images support NASA astronaut candidate training.

The Tibetan Plateau showing Gozha Lake and mountain glaciers, taken from the International Space Station, demonstrates how astronaut photographs provide recognizable images. That makes them accessible for a wide range of applications without users needing remote sensing expertise. Credit: Earth Science and Remote Sensing Unit, NASA Johnson Space Center

Apart from supporting scientific research, images from the space station often show up in movies, YouTube productions, and advertising, and contribute to educational uses, including school science projects.

One advantage of the photographs, taken with handheld digital cameras, is their similarity to those people might take out an airplane window, Stefanov points out. "You can look at an image and pretty much grasp what you are seeing without an explanation, as opposed to, say, a false-

color hyperspectral image. You don't need to be a remote sensing expert to understand the data. That's very powerful, particularly on the education side."

CEO imagery is free to the public. Users can access the database at any time at Gateway to Astronaut Photography of Earth. A query page offers several ways to investigate existing data, and researchers and educators can request new imagery as well.

NASA's Earth Science and Remote Sensing Unit (ESRS) at Johnson Space Center works to enhance the scientific usefulness of astronaut photography from the space station, adding geo-referencing to disaster response images to help users incorporate data into response activities, for example. NASA is also developing machine-learning applications to classify features in the images automatically.

The agency has collected photographs of Earth from space since the early Mercury missions beginning in 1961, Stefanov adds. "This is a pretty incredible data set."

More information: Aaron E. Schirmer et al. Mapping behaviorally relevant light pollution levels to improve urban habitat planning, *Scientific Reports* (2019). DOI: 10.1038/s41598-019-48118-z

Provided by NASA